INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
MATERIALS MANAGEMENT DIVISION
Powai, Mumbai 400076.

Technical Specification of Inconel – 718 (Qty – 121 Nos.)

Sr. No.	Description				Compliance Yes/No
1 [R]	**Scope:** This specification covers the requirements for premium quality nickel base superalloy - 718 grade forged / hot rolled bars up to ruling section of 100mm for machining ofcomponents, requiring high strength and oxidation resistance, for use in gas turbine engine for aerospace applications.				
2	**Applicable / Control Documents:**				
	(a) Inspection and QA procedure	BS-HR-100			
	(b) Testing procedure	Appropriate ASTM / AMS / BS specifications			
3 [R]	**Chemical Composition [in % weight] :**				
	C : 0.02 - 0.08	Si : 0.35 (max.)	Mn : 0.35 (max.)	P : 0.015 (max.)	
	S : 0.015 (max.)	Cr : 17.0 – 21.0	Ni : 50.0 – 55.0	Mo : 2.80 – 3.30	
	Nb * : 4.75 – 5.50	Ti : 0.75 – 1.15	Al : 0.30 – 0.70	Ta * : 0.10 (max.)	
	Co : 1.0 (max.)	B : 60 ppm (max.)	Cu : 0.30 (max.)	Sn : 50 ppm (max.)	
	Ag : 10 ppm (max.)	Ca : 0.01 (max.)	Mg : 0.01 (max.)	Pb : 5 ppm (max.)	
	Bi : 0.5 ppm (max.)	O : 150 ppm (max.)	N : 140 ppm (max.)	Fe : Balance.	
	* Nb + Ta : 4.75 – 5.50				
	(a) Absolute level of Boron need not be reported. However, it is required to be certified that it is less than the maximum limit specified. (b) Tantalum need not be reported separately. However, Nb+Ta to be analysed and reported.				
4 [R]	**Ingot manufacture:** VIM + VAR or VIM + ESR.				
5 [R]	**Heat Treatment:**				
	(a) Solution treatment: Heat the material to a temperature in the range of 950 - 980°C , holding one hour at the selected temperature within ±10°C, and air cool, oil or water quench. The selected temperature and the cooling method shall be reported in the test certificates.				
	(b) Aging: Heat to a temperature 720 ±5°C for 8 hours, furnace cool at 55°C/hr to 620 ±5°C, hold at this temperature for 8 hours then air cool.				
6	**Condition of Supply:** As forged/hot rolled, solution heat treated and machined or ground condition, unless otherwise specified.				
7	**Mechanical and Metallurgical Properties:** The properties shall be evaluated on the product in solution treated and aged condition as per Clause-5 of this specification.				
	(a) Hardness: 331 BHN (min.) in solution treated & aged condition.				

(b) Tensile Properties:

Properties	TEST TEMPERATURE			
	RT		650°C	
Sample Orientation	**Longitudinal**	**Transverse**	**Longitudinal**	**Transverse**
0.2% YS (min.)	1030 MPa	1030 MPa	860 MPa	860 MPa
UTS (min.)	1270 MPa	1240 MPa	1000 MPa	960 MPa
% El. [in 4D / 5D], min.	12% / 10%	6% / 5%	12% / 10%	6% / 5%
% RA, min.	15%	8%	15%	8%

(c) Combined Smooth and Notch Stress Rupture Test as per ASTM-E-292.

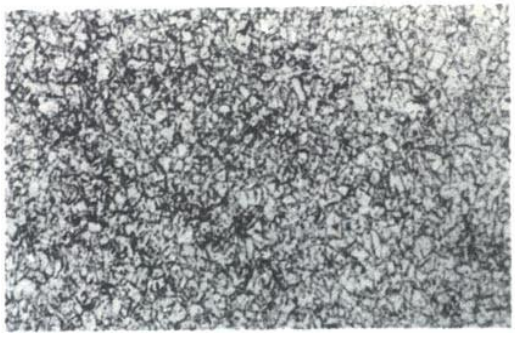
Temperature	650°C
Minimum Axial Stress	690 MPa
Life (min.)	23 hours
Location of failure	Smooth section
% Elongation [4D] at Smooth section (min.)	4%

8 [R] **Macrostructure:** Macroexamination shall be carried out on two slices corresponding to top and bottom portion of the ingot at a suitable stage of manufacture preferably at 100mm square or 100mm diameter. Macrostructure shall have substantially uniform structure and free from any segregations, voids, inclusions, dirt and dross at a magnification of 1X. The presence of any freckles shall be cause for rejections. White spots of size less than 3mm, less than 4 in number and distribution limit of Severity-'B', Class-2 of ASTM-A604 shall be acceptable. If it exceeds the above standards, it shall be subjected to micro-examination and would not be acceptable, if any of the following is noticed:

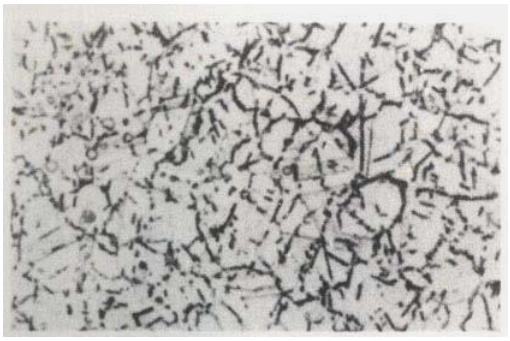
(a) Absence of delta phase.
(b) Hardness difference between the matrix and the white spot is more than 30 VHN.
(c) Grain size difference between the matrix and the white spot is more than 1.5 ASTM.
(d) Presence of oxides, carbonitrides, voids, dirt or dross.

9 [R]	**<u>Microstructure</u>:** Microstructure shall be examined on minimum two samples of the product, corresponding to top and bottom of the ingot. The structure shall be substantially uniform and free from Laves phase, banding of acicular phases and clustering of undesirable phases. **(a) <u>Grain Size:</u>** - **For sizes with cross sectional area up to 58 sq. cm** : Average grain size of ASTM 5 or finer with occasional grains as large as 3 are permissible. - **For sizes with cross sectional area more than 58 sq. cm** : Average grain size of ASTM 4 or finer with occasional grains as large as 2 are permissible. **(b) <u>Delta Phase</u>:** Ni_3Nb(delta phase) distribution levels shall be evaluated. The acceptance and rejection standards of various distributions of the delta phase are shown at Fig. 1–11.	
10 [R]	**Non-destructive Testing:**	
	(a) Ultrasonic Inspection: The products shall be subjected to 100% ultrasonic testing as perAMS-2630B specification and the minimum acceptance standards are as follows: (i) Single discontinuity of 1.2mm FBH. (ii) Noise level shall not exceed 50% of DAC. (iii) Attenuation check shall be carried out on the product with the first back-wall echo reflection below the vertical limit and variation in back-wall reflection from one location to the other within the same product shall not exceed 50% [6 dB].	
	(b) Fluorescent Penetrant Inspection [FPI] : After completion of all processing operations,the products shall be subjected to 100% FPI as per AMS-2645H.	
11 [R]	**Notes:** 1. The [R] symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of this specification. 2. In general, the material manufactured to AMS-5662 specification shall be acceptable against this specification. However, all the technical requirements, which are not covered by the AMS specification but required as per this specification, shall also be ensured on the product. 3. In addition to detailed description of products and test results, the actual heat treatment cycles followed on the products/test coupon and the test parameters for mechanical properties evaluation shall also be reported in the test certificate.	

Inconel 718 Delta Phase Morphology Standards

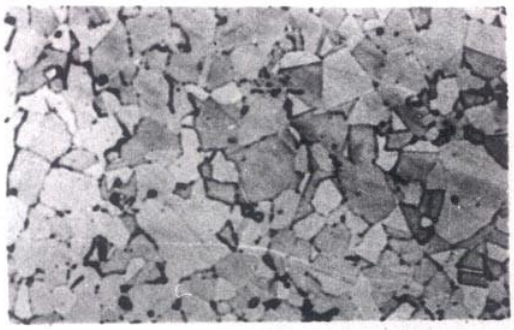


100X Magnification



400X Magnification

Fig. 1 : DISCREET DELTA PHASE PARTICLES - ACCEPTABLE



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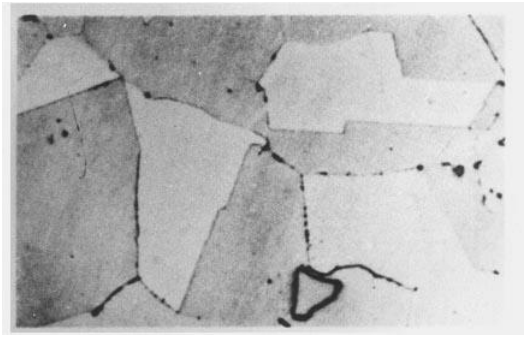
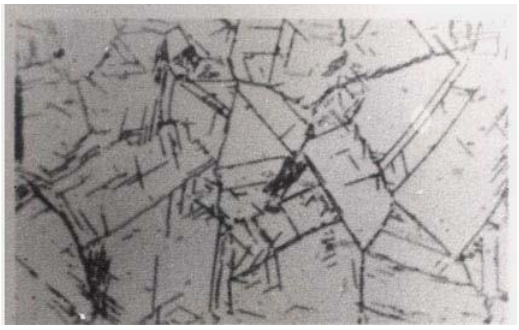


400X Magnification

Fig. 2 : ALMOST NO DELTA PHASE - ACCEPTABLE

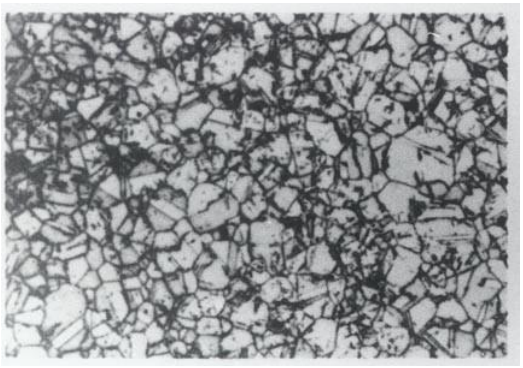
100X Magnification



400X Magnification

Fig. 3 : GRAIN ACICULAR DELTA PHASE - ACCEPTABLE

Inconel 718 Delta Phase Morphology Standards



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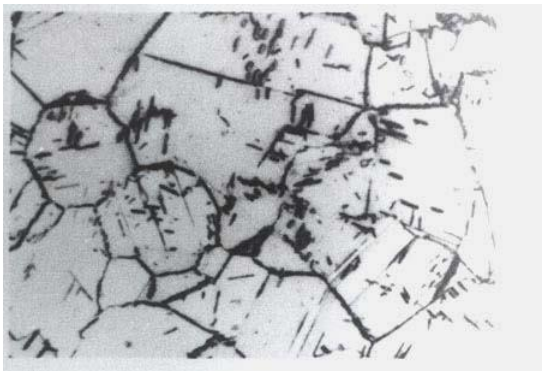
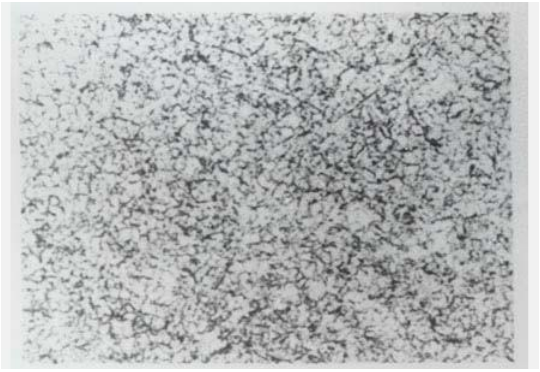
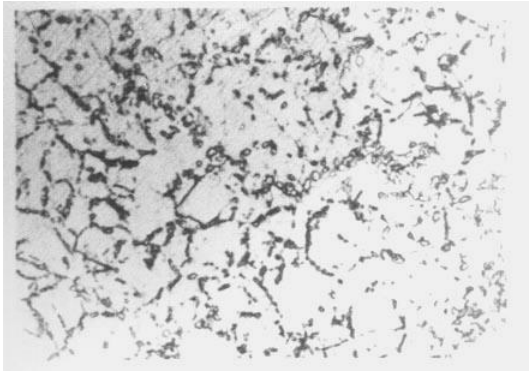


400X Magnification

Fig. 4 : GRAIN BOUNDARY ACICULAR DELTA PHASE - ACCEPTABLE



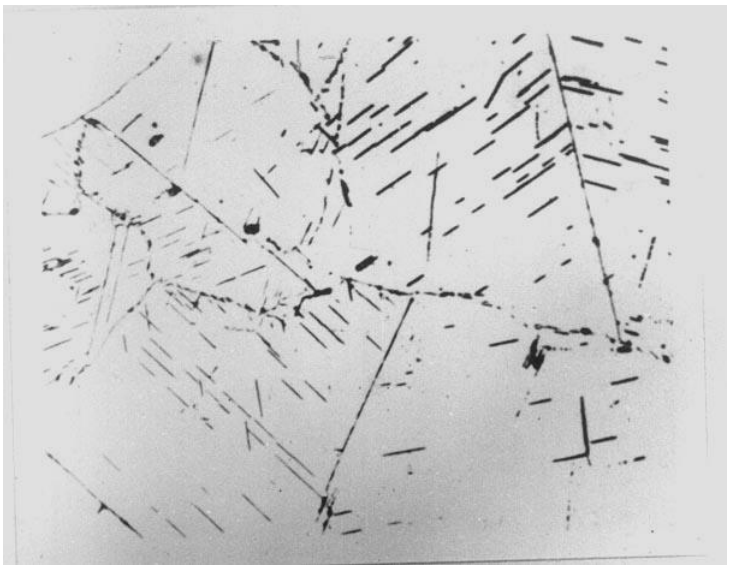
100X Magnification



400X Magnification

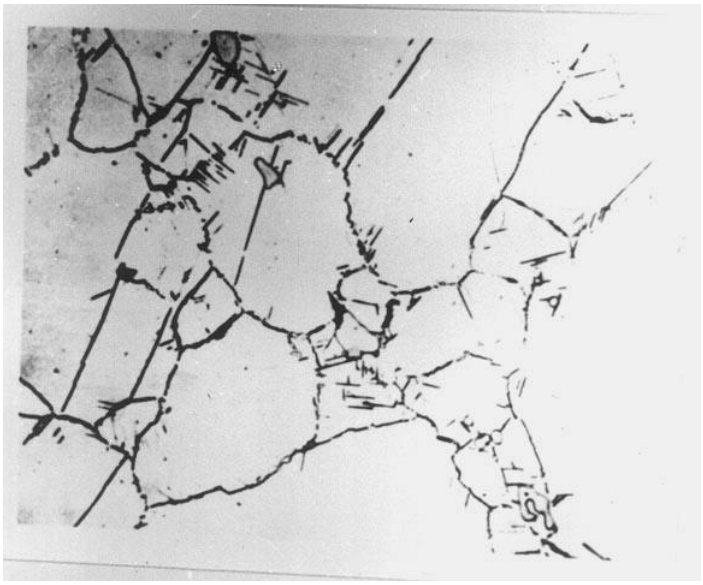
Fig. 5 : SPHEROIDISED DELTA PHASE - ACCEPTABLE

Inconel 718 Delta Phase Morphology Standards



400X Magnification

Fig. 6 : MODERATE AMOUNT OF NEEDLE PHASE THAT APPEARS PRIMARILY WITHIN THE GRAINS - ACCEPTABLE



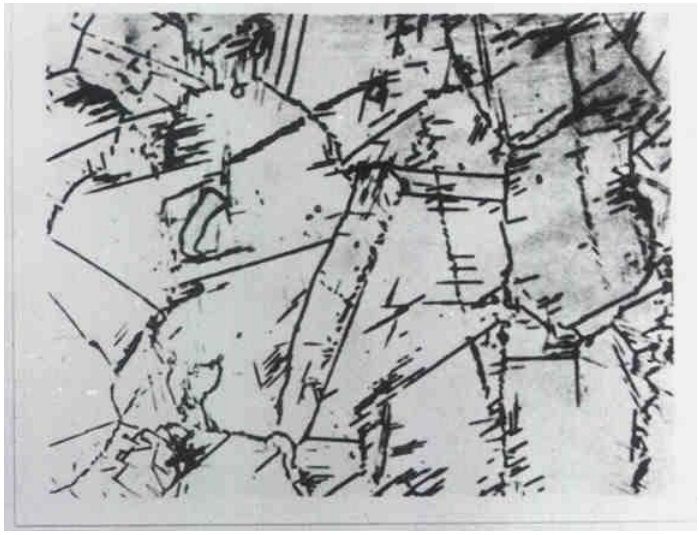
400X Magnification

Fig. 7 : SLIGHT AMOUNT OF NEEDLE PHASE RESTRICTED PRIMARILY TO THE GRAIN BOUNDARIES - ACCEPTABLE

Inconel 718 Delta Phase Morphology Standards

400X Magnification

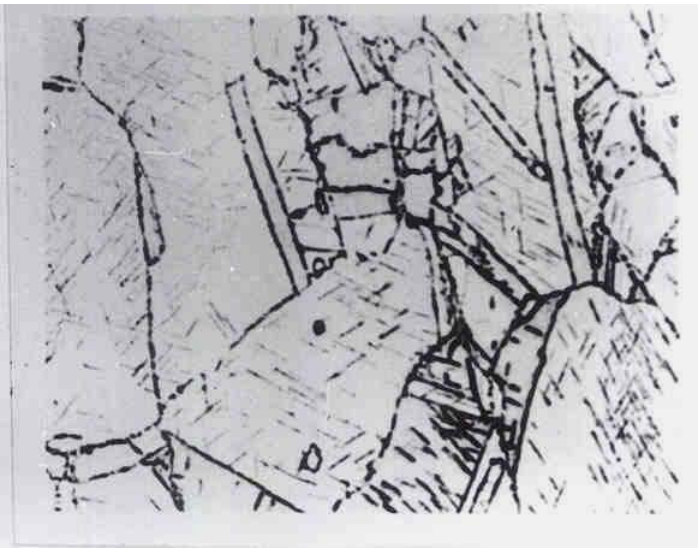
Fig. 8 : SPHEROIDAL DELTA PHASE - ACCEPTABLE



400X Magnification

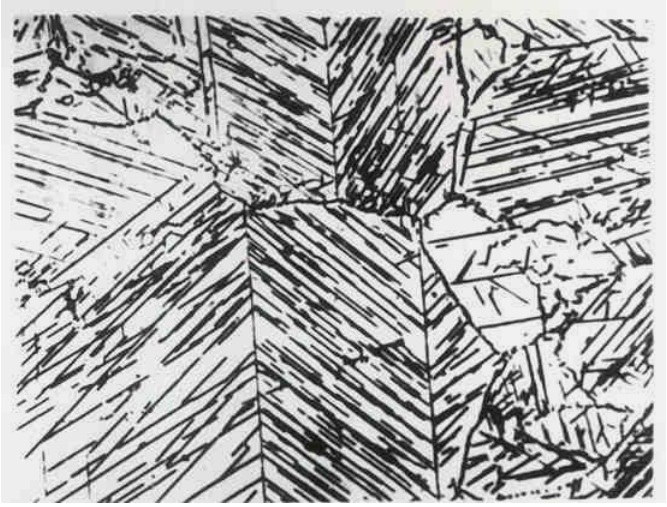
Fig. 9 : GREATER AMOUNT OF NEEDLE PHASE. IT APPEARS BOTH AT THE GRAIN BOUNDARIES AND WITHIN THE GRAINS - UNACCEPTABLE

Inconel 718 Delta Phase Morphology Standards



400X Magnification

Fig. 10 : INCREASED AMOUNT OF INTRAGRANNULAR NEEDLE PHASE - UNACCEPTABLE



400X Magnification

Fig. 11 : LARGE AMOUNT OF NEEDLE PHASE WITHIN GRAINS - UNACCEPTABLE